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NEWER METHODS IN PERIMETRY AND THE CHARACTER OF STUDIES FOR WHICH THEY ARE ESPECIALLY ADAPTED*

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BEFORE taking up the subject offered for discussion, I wish to express to the Master and Council and to the members present my deep appreciation of the honour of the invitation to open the discussion and the privilege of taking part in the scientific programme of this Congress.

It is a very great pleasure indeed to meet personally so many of you whom I have known only by reputation and by your contributions to this great science, and it is equally gratifying to be permitted to discuss with you some of the problems of ophthalmology, which, though old, are young in interest.

The theme selected by the Council opens up many avenues of approach. It would not be doing justice to the subject nor would it be fair to the members of this Congress to attempt to include in a single communication all the interesting paths which we might follow. It was suggested, therefore, that I limit my remarks to "Newer Methods" and the particular types of cases for which they are especially adapted.

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During the course of the discussion it is not unlikely that some of you may feel disinclined to accept without reservation some of the views which may be presented touching upon certain phases of the subject. They are, however, the result of honest convictions arrived at, not hastily, but only after due thought for some years past in private and hospital practice and in the class room. If any opinion expressed seems to be lacking in a truly orthodox ring, may I ask that you withhold final judgment until you have put it to a practical test and have fully satisfied youselves that it is or is not tenable. The fact that we may not all agree should not deter us from the freest expression of opinion, as only by such frank interchange of thought and experiences can we hope to make progress.

It will be well at the outset to distinguish clearly between what may be called laboratory methods, such, for example, as are practised by physicists in establishing varying degrees of retinal sensitivity to form and colour stimuli, and practical methods such as may be used in routine office practice to determine the presence or absence of a pathological process and the approximate extent of such process. It is the latter group of procedures which we have in mind in this discussion. Were it not for the time element and the technicalities involved in laboratory methods, it would be ideal to apply these accurate tests to our clinical investigations. Our nearest approach to accuracy can only be reached by adopting, so far as possible, laboratory procedures modified so as to bring them within the practice of the average ophthalmologist. For example, by special light control and the use of spectral colours[1], yellow, blue, and red are recognized as far in the periphery as form. It is not possible to obtain such correct scientific standards, however, in the average office, much as it is desirable, and we are therefore obliged to accept as our standards the colour limitations which have long been recognized.

In a communication before the Ophthalmological Society of the United Kingdom in 1905[2], Mr. Sinclair quoted from Helmholtz the following: "The entire field corresponds to a drawing, in which the important feature is carefully executed in detail, while the other parts are roughly sketched in, and the more roughly the further they lie from the important feature." Along with our increasing knowledge of perimetry has come a realization of the importance of a study of the special feature and this special feature for the most part is found in the central zone. The silhouette of the field, although valuable in so far as it goes, gives little intimation of the individual characteristics or defects which the preserved field may possess. The classical perimeter, in principle scientifically constructed, and practical in delimiting the outlines of a given field, fails utterly in the important work of studying changes peculiar to the central zone. In order to make these studies, one is obliged to

select an instrument more elastic in operation and more delicate and pliable in manipulation than the conventional and clumsy perimeter in its present form.

The von Graefe[3] and de Wecker[4] tangent screen has furnished us with the principle, the adaptation of which has entered into the construction of modern instruments. As the value of the principle of the stereoscope is indicated by the great number of modifications which the original stereoscope has undergone, so the value of the tangent screen is reflected in the great number of modifications of the original tangent plane, which make up our modern equipment. Each modification possesses a peculiar adaptability for the study of a specific type of case, and this specialization, as it were, has also narrowed the scope of work for which it is adapted. This is well illustrated in the stereo-campimetric slate of Lloyd, of which we will have occasion to speak later. The tangent plane is now the instrument of choice in all central field studies.

That an element of error* may creep into the findings between the twenty and forty degree area is admitted if a movable stimulus is employed. This error, however, is so small that it becomes negligible, particularly in the type of plane which now is in more common use.

One of the most marked advancements made in the tangent plane is its use in certain studies at close range. For rapid, practical and routine work this is a decided improvement, and balancing up the advantages gained thereby and the disadvantages, it marks a step in the right direction.

I am not sure that we can entirely ignore the claims of those who feel that perimetry requires too much time. Having in mind this objection, by shortening the working distance of the campimeter, I have been enabled to evolve a practical working hand campimeter,[8] which admits of speedy and accurate operation not only in studies of the central zone but also of a large part of the peripheral field. In addition to shortening the working distance, the average normal blind spot of Mariotte has been definitely placed and outlined on the screen, so that the blind spot may be studied with ease. In fact, it is my custom to begin the study of the field by outlining the normal blind spot. There is a double advantage in this procedure. First, one makes a routine habit of measuring the blind spot, and thereby develops very helpful information in unsuspected cases of its enlargement. A second advantage lies in the training which the patient receives in

* The defects of the campimeter are well known. For a more detailed study of the comparative value of the perimeter and campimeter the reader is referred to the author's text-book, "The Principles and Practice of Perimetry"[5], to "Campimeter *versus* Arc Perimeter"[6], and to "The Value and Limitations of Perimetric Methods of Study"[7].

concentration. In my experience, holding the patient's attention is one of the difficulties in perimetry; at the same time it is the *sine qua non* of field taking. I am partial to this hand campimeter for a major portion of routine field studies, not because it is an instrument of my own designing *per se*, but because it is the product of a long series of studies leading to the construction of a campimeter with the widest range of applicability consistent with accurate results, ease of operation and with the fewest disadvantages—in other words, a practical routine instrument. That it has accomplished its mission far beyond expectations is evinced by the large number now in use in the United States. In the hands of those who have given it a fair test and have acquired its technique, it has practically displaced the perimeter, the latter instrument being reserved for the few cases in which nearly normal fields must be taken. It is hardly within the scope of this paper to dilate on its merits further than to point out its especial adaptability to certain phases of study. In fact, it needs no defence in its radical shifting of the distance at which studies are made as the practical results yielded furnish the most convincing of arguments.

A type of plane similar to the hand campimeter, but operated at a distance of sixty centimetres, has been constructed by Gradle, of Chicago.[9] There is much to commend in Gradle's instrument. A second point of fixation is interposed midway between the patient's eye and fixation point on the board. This holds the patient's attention and insures more uniform alignment. As on the hand campimeter, the average normal blind spot is marked out so that enlargements are easily recognized. The principal point of excellence lies in the method of presenting the stimulus to the patient's eye. The test objects consist of metal balls of definite sizes, which are moved on the tangent surface by a magnet from behind the screen and only the small ball is visible to the patient. This, however, is purely a laboratory instrument, as the author himself states, "the instrument is too technical for general adoption in routine office practice."

The Bjerrum method of study at long range, two metres from the board, with minute test object, has not grown into favour, at least in the United States, except for special studies. These larger types are especially adapted to the study of the tubular field, to the outlining of small scotomata which elude accurate study at close range, to an analytic study of the blind spot of Mariotte in accessory sinus disease, in glaucoma, etc., *at a one metre radius* and to the plotting of the light field in mature cataract.

Possibly the greatest progress in our modern methods within a limited range of applicability is the evolution of the original stereoscopic method of study by means of Haitz's charts, to the

large angled stereoscopic slate of Lloyd, of Brooklyn.[10] The wide angled stereoscope has made it possible to include for study an area extending about twelve degrees to the nasal side, twenty-five degrees down, twenty-five degrees above the fixation point, and thirty degrees to the temporal side. Within these limits, and with central vision preserved in one eye to insure perfect fixation, no instrument at our command offers so much in accuracy of study and ease of operation. Even though the radius is but 205 millimetres, the outlining of a scotoma and of the blind spot of Mariotte is accomplished accurately and more expeditiously than with any of the larger types of tangent screens.

A discussion of newer methods before this Congress would not be complete were we to omit the scotometer which Col. Elliot has devised.[11] As this is a frank expression of a personal opinion, Col. Elliot will doubtless pardon any adverse criticism of his instrument if the criticism is given in order to get at the truth.

The screen for the most part is an excellent one, and if great care is exercised in its operation, accurate results can be obtained. For reasons which will appear later in this communication, the test objects might advantageously be enlarged. The objection which I regard as quite important, but which may be removed by very deliberate and careful manipulation of the instrument, is its *inelasticity*. It is the same objection which must necessarily be raised against the perimeter or any automatic scotometer in which the test object is mechanically moved along a fixed line either circumferentially or radially. Any such device, if care is not exercised, may lead to artefacts and findings far from the truth. One of the greatest difficulties which the student encounters is to outline an irregular defect. He persistently develops sharp angles which rarely exist, and misses indentations which may be present. This is largely the result of moving the test object mechanically, as it were, in a groove. Only when the test object is carried over a tangent surface by hand, or by such device as Gradle employs, or by great care with the Elliot scotometer, will a real angular defect be reproduced true to nature.

The essential principle upon which the newer methods of study are based is *flexibility*. In the operation of the perimeter one is constantly conscious of working in a groove, and feels the need of greater freedom of manipulation of the test object. The tangent plane admits of this freedom and, therefore, has been accepted as a distinct improvement over mechanical devices which operate in set grooves and channels. While mechanical scotometers overcome some of the marked defects of the perimeter, they tend to neutralize the chief advantage which the campimeter possesses, namely, *elasticity*. If we divest the campimeter of this attribute, from a clinical standpoint, there is little in it to commend, and the

perimeter may as well be reinstated into popular favour. Were we, however, to choose between a radial or circumferential mechanical movement, we would undoubtedly choose the latter.

It is not possible in so brief a paper, nor is it germane to the subject, to refer to all the perimeters and tangent planes which have been contributed on this and the other side of the Atlantic. It is necessary to confine our discussion to principles and to newer methods and instruments which offer some modification of established principles and customs. In passing, however, it is interesting to note that in the *Transactions of the Ophthalmological Society of the United Kingdom* for 1918 no fewer than eight varieties of perimeters and campimeters were reported among the Museum specimens.

Before taking up the special adaptability of these newer methods to specific types of field studies, two particular phases of the subject need further elaboration, namely, the distance of the eye from the tangent plane and certain phases of the test object. Between the Bjerrum method of study with minute objects at long range, and the author's hand campimeter or Schweigger's hand perimeter at close range, there is considerable difference on first thought. To reconcile the two methods it will be necessary to weigh the evidence for and against in each instance.

To the examination at close range the following objections are raised: First, the test object, even though small, stimulates a larger number of perceptive end organs and, therefore, is not so analytic as when the same test object is used at a greater distance. Second, in presbyopes and hypermetropes vision is not accurate at close range. Third, an error at this distance is proportionately greater than when studies are made at a longer distance.

The first objection is hardly valid since in any central study one chooses the smallest object that can be clearly seen. At one metre distance a test object one millimetre in diameter is an unsatisfactory stimulus for anything but white at twelve centimetres beyond the fixation mark. If there is doubt in the mind of anyone as to the correctness of this statement, he can easily verify it by attempting to make reproducible colour or even form studies under these conditions. Furthermore, if the assumption is correct that one of the chief functions of the peripheral retina is the recognition of moving objects as well as objects at rest, it is not essential that a test object should be so small as to stimulate only one rod or cone. As a matter of fact, it is hardly possible in the peri-macular region to use a test object so small as to stimulate but one end organ. As the peripheral zone is poorly supplied with rods and cones, and the stimulus becomes less well-defined in the extreme periphery, a moving stimulus is logically the proper test object to employ in order to determine peripheral sensitivity. To overcome this

falling off in peripheral sensitivity, the intensity of the stimulus should be increased or the size of the test object should be enlarged. In lieu of these measures a slight movement imparted to the test object tends in a measure to better peripheral stimulation. There is nothing gained, therefore, by a minute test object unless one is making careful laboratory quantitative studies of the peripheral retina. (Since writing this paper I noted in re-reading the chapter on Perimetry by H. Wilbrand[12], in Norris and Oliver, that Wilbrand calls attention to the value of this method and quotes Aubert to the same effect.)

The second objection is equally without foundation since suitable glasses can and should be worn for central studies if vision is defective. A presbyopic correction may be worn with advantage. The same objection may be raised in testing a myopic patient on a screen or perimeter of long radius. One cannot hope to work at all times under ideal conditions when the subject cannot be selected as in physiological studies, but a pathological clientèle with normal and abnormal refractive conditions are presented for investigation. It is essential that we meet conditions as we find them in practice and that ametropia shall receive due consideration before field studies are attempted. If it is not possible or feasible to correct such errors, the tangent plane with a radius suitable for the patient should be selected.

The third objection has an element of truth in it. An error is proportionately greater as the radius of examination is shortened. Care, however, can overcome this.

The great advantage at close range is the sharp definition which the patient is able to make. Variations in the colour tones are definitely and promptly recognized as full saturation of colour is approached. Purity of colour depends directly upon the intensity of the illumination. As it is also influenced by the distance of the eye from the illuminated surface, it is absolutely essential that the angle of the colour stimulus be sufficiently large to excite colour vision, and this is brought about either by increasing the size of the stimulus or by shortening the radius of the arc. In laboratory studies it is accomplished by increasing the intensity of the illumination.

A second great advantage at close range is the ease with which concentration on the point of fixation can be maintained by the patient. To appreciate fully the second fact, one must have practised and be familiar with both methods.

It is well to bear in mind that binocular fixation should be employed at all times when feasible as it insures better and more comfortable fixation. This applies especially to blind spot studies, and can easily be executed on any tangent plane by holding a piece of cardboard in place between the eyes.

The difficulties encountered in testing out a patient by small objects at long range are, first, the inability to secure constant and *reproducible* results. If the patient is fairly intelligent, approximately uniform answers may be obtained, providing a white test object is used, and this sufficiently large. The element of fatigue necessarily contributes to this uncertainty when the test object employed subtends too small an angle, such, for example, as is recommended by the Bjerrum method of a two-metre radius. In the second place, as the threshold for colours is a variable quantity depending upon individual sensibility and variability in the illumination, etc., when the third factor is added, namely, *pathology*, the uncertainty of the point where a colour is distinctly recognized, is increased. This uncertainty is augmented by moving the patient farther from the board, and diminished either by bringing the eye closer to the tangent surface or by increasing the diameter of the test object. In my experience, bringing the eye closer to the screen offers the best results in the greatest number of cases, because it increases the intensity of the stimulus, and enlarges the angle which the stimulus subtends. In this connection it is interesting to note that Ferree and Rand, in their important studies of retinal sensitivity, in the Physiologic Laboratories at Bryn Mawr College, used a tangent plane which they designated as a rotary campimeter, and that most of these studies were made at a radius of twenty-five centimetres[13,14]. The advantage of working at a metre distance is that a careful analysis can be made of a defect which has been uncovered by routine methods. It admits of more minute study of a small or large scotoma, provided the test object used subtends the same angle as that which is employed on a plane of a shorter radius. This advantage, however, is only obtained when the radius is not over one metre, and the size of the test object is uniformly maintained.

Briefly, therefore, the short plane is best adapted for routine studies because it accomplishes its purpose expeditiously and with fair accuracy. The plane of a one metre radius admits of more careful analysis of the "important feature" referred to by Helmholtz.

The test object.—Newer ideas in reference to the stimulus can best be studied under the following headings:

a. Nomenclature.

b. The size of the stimulus.

c. Method of exposing the test object to the eye especially in the peripheral field.

d. Direction in which the test object should be moved.

e. Fixed stimulus.

a. The manner of designating the size of the stimulus needs special consideration. The size of the test object used in the past was

designated as a rule in millimetres.[15] In view of the great number of perimeters and campimeters with varying radii now in use, linear measure is inappropriate because we are dealing with angles, and unsatisfactory because the angles which the same test object will subtend must vary with the length of the radius. For example, to say that a five millimetre test object was used in developing a certain field means really nothing definite unless the radius of the instrument is given; and if one is accustomed to operate on a perimeter or campimeter of a longer or shorter radius, the designating of the test object in millimetres is confusing. To speak of the size of the stimulus in degrees or minutes, therefore, is in the interests of uniformity and has done much to simplify what has been rather vague and indefinite in the past. Changes of this kind require time to inaugurate thoroughly, but it is one of the newer methods which undoubtedly will and should replace the old.*

b. The size of the test object.—Little has appeared in literature[16] of a definite character as to the exact size of the test object. It has generally been understood that an object five millimetres in diameter was considered as a standard for measurements on a perimeter of 330 millimetre radius. On the Bjerrum screen a test object as small as one and two millimetres was recommended. Reference has already been made to the objections to so small an object for satisfactory work. In certain individual cases the size of the object will be determined by the state of vision. When visual acuity is much reduced, the test object to be used should subtend the smallest angle compatible with clear vision. For general use we can be more specific. Within the twenty degree circle, a one-half degree or thirty minute test object is the smallest stimulus which will yield uniform, and, therefore, satisfactory results. At one metre this test object will measure 8.75 mm. in diameter. On the author's hand campimeter it will measure 1.5 mm. and on the average perimeter of a thirty-three centimetre radius, approximately 3 mm. For colour studies even this is too small and a one degree object is more satisfactory. For peripheral retinal studies a two degree test object should be our standard. It is well known, of course, that an increase in the size of the test object tends to a larger field, or to put it in a way which is nearer to the truth, diminishing the size of the stimulus tends to contract the field. This is especially true if the test object is smaller than one degree. For routine studies, therefore, it is important to have a fair and reasonable standard and for peripheral retinal sensitivity, it is my belief that two degrees is a safe limit as this will apply to colours as well as to form. It is not fair to apply

* The size of the test object has been expressed in degrees in a number of instances recorded in literature, but no one, so far as I have been able to discover, has ever insisted that it should be uniformly so expressed.

central visual acuity tests to peripheral vision. According to Dor,[17] a point five degrees excentric to the fovea has but one-fourth the visual acuity of the fovea; at twenty degrees it is but a fortieth, and at forty degrees the acuity is one one-hundred-and-twentieth of that of the fovea. If fifty to seventy seconds is the angle usually required for definite special perception, a stimulus considerably larger should be employed for peripheral stimulation. Studies by Ferree and Rand[1] led these investigators to the conclusion that chromatic sensitivity of the retina fell off moderately up to a given point and then very abruptly, so that a great increase in the intensity was necessary to register any perception of colour. It is essential, therefore, that the stimulus employed be of sufficient size to make the testing of the peripheral field of some value. Although it will be impossible, perhaps, to obtain laboratory accuracy, an average field for each colour can be established by means of the attempts at the standardization proposed. The use of a uniform size in the stimulus for peripheral studies will furnish one step in the direction of standardization. A stimulus of two degrees should be the minimum angle subtended.

c. While discussing the test object, it is opportune to speak of the ***technique of exposing the stimulus to the eye,*** a point which is rarely dwelt upon. A special function of the peripheral retina is the detection of moving objects as well as response to stationary stimuli. It is my custom, therefore, to approach from beyond the field of vision to the most peripheral visual point in a deliberate manner, imparting a slight vibratory movement to the stimulus. This furnishes the sort of stimulus from which the peripheral retina is physiologically best adapted to receive impressions.[12] It is, however, impracticable on any mechanically operating perimeter or campimeter and can only be practised when the test object is in the dexterous hand of the operator. The detection of a moving object is not the only function of the peripheral retina. It is, however, a most important one, and, according to Spiller[18] and Riddoch[19], probably one of its primitive functions. According to the same authorities, it is the last function to disappear and the first to reappear in atrophic or nutritional disturbances. At all events, it is a most important function, and it undoubtedly marks the extreme boundary of vision. When the question of minute peripheral loss is under consideration, routine studies can be supplemented by quantitative tests in which the periphery is studied by test objects varied in size or more correctly by the physiological method of varying the intensity of the stimulus. The vibration of the test object is of exceptional value in obtaining satisfactory results in illiterate patients, in much contracted fields and, in general, helps to reduce the time of "field taking." Movement of the test object is not necessary nor advisable in a great number

of cases, but those of you who have practised "field taking" routinely will appreciate the advantage of this method in a certain number of difficult cases.

d. What perhaps is not new, but about which our newer ideas are very definite and possibly dogmatic, is the manner of approach to the visual line, whether to pass the object from visible to invisible or the reverse. In my own studies and in my class room, the test object is always passed from a blind area to a functioning part of the retina. This is observed not only in the periphery but in the blind spot of Mariotte and in other scotomata. If I may be permitted again to refer to Col. Elliot's scotometer, and the very remarkable irregularities which the instrument develops, it has occurred to me that the irregularities may in a measure be due to the fact that certain parts of the outline are developed by passing the object from functioning to blind retina and other points from blind to functioning retina. The desire of the average patient to help and please and make a good showing is encouraged by passing from a visible to an invisible point in the field. It rarely is dependable. Fixation is less apt to wander when the image is passed from invisible to visible. It is my belief that a blind spot should be developed from within the blind area outward and the peripheral field from without towards the centre of fixation. It is hardly necessary to say that in outlining the blind spot of Mariotte, or any central scotoma, the object should be passed back and forth in both directions until the boundary is definitely fixed. This is particularly necessary in outlining that part of the scotoma which is most remote from the point of fixation.

e. A fixed stimulus.—A method which has been followed with excellent results in physiological studies of peripheral retinal sensitivity is that of fixing the test object and having the patient rotate the eye—a movable fixing point. This method is employed in order to use spectral colours and standard illumination. In the Bryn Mawr College Physiologic Laboratories, Drs. Ferree and Rand have done most excellent work in physiological investigation by means of this method.[20] Doubtless other physicists follow the same routine. It requires a rather difficult *technique* for adoption in routine office practice, much as it would be desirable to practise perimetry with spectral colours and uniform illumination. For pre-exposure and surrounding field, which Drs. Ferree and Rand insist are important factors in peripheral retinal studies, it is well adapted. It is, however, too distinctly a laboratory procedure to be adopted in routine office practice.

What can be said in favour of the most recent types of automatic perimeters, equipped with test objects of coloured glass through which light is transmitted? Like most of the so-called improvements of the perimeter, which really possess no merit other than

as time saving devices, this form of illumination has added nothing of value. It opens up an avenue of discussion which would lead us too far from our theme. It is sufficient to say that this form of illumination adds but another serious defect and complicates rather than simplifies our efforts at standardization. If the perimeter is to be used at all, best and most accurate results will be obtained by using it in its simplest form, namely, the original Förster model without the sliding carriage but with hand manipulated test objects adapted to its radial length. These objects should be similar in form to those used on the Lloyd slate, or the test objects as suggested by Ferree in his new model exhibited before the American Ophthalmological Society, June 15-16, 1920.[21]

In view of the excellent work done by physicists and especially by Drs. Ferree and Rand in physiological studies of the blind spot, of relative retinal sensitivity and light standardization, a few moments should be spent in summing up what seems to be suitable for our adoption in the methods which they employ.

First, *Illumination.*—The contributions of Ferree and Rand to illumination in perimetry,[21 22] are noteworthy. To the perimeter a "daylite" lamp unit has been added which distributes a band of uniform light in one meridian and as this lamp moves with the arm of the perimeter, the examination is conducted at all times under fairly uniform conditions. They have, therefore, reduced to a practicality a method of illuminating the perimeter which can be practised wherever electricity can be obtained. This contribution to the perimeter has enhanced its value in peripheral studies. This same "daylite" unit has been used in the author's office for illuminating the campimeter for several years past. While the illumination of the flat surface is perhaps not so uniform as the Ferree-Rand method on the perimeter, it is sufficiently accurate for all practical purposes.[23]

Second, *Spectral colours.*—It is not possible to use spectral colours excepting in well equipped laboratories. The adoption of mixed pigments expressed as nearly as possible in definite wave lengths, is the nearest approach to spectral colour test objects suitable for our work.*

Third, *Fixed stimulus.*—A fixed stimulus is peculiar in that it reverses the order of investigation to which we are accustomed. For the outlining of the entire peripheral field it is not practical, neither can it be readily applied for the studying of a scotoma in the central field. Because of the limitations in ocular rotations, the head must be moved in order to be able to reach, for example, a 90° point of excentricity. To work in all necessary meridians would be too time consuming and intricate for routine work. In order

* For a more detailed suggestion as to standardization of the colours, the reader is referred to the author's "Uniformity in the Essentials of Perimetry."[15]

however, to determine light sense for any given point in the retina by accurate photometric measurements, it may have a field of usefulness in well equipped offices.

Fourth, *Pre-exposure and surrounding field.* More stress is laid by Ferree and Rand on pre-exposure than on surrounding field. They are the first[21] so far as I know,* to endeavour to bring these most essential principles within the practice of busy ophthalmologists. In the suggestions offered by them to improve the value of the perimeter or to reduce its peripheral field work to greater accuracy, they have suggested a plan by which surrounding field is controlled and the retina involved in study may be properly pre-exposed. For a detailed description of this perimeter the reader is referred to the *Transactions of the American Ophthalmological Society*, 1920. To one who approaches the subject from a clinical standpoint with a full knowledge of our peculiar needs and difficulties, the principle involved strongly appeals, but the special method of applying it to the perimeter does not appeal. It possibly may be the best solution of a difficult problem, but from a practical standpoint it seems to burden the perimeter unnecessarily rather than simplify it.†

However, if the claims of these investigators[22] are correct that an error in the peripheral field of as much as twenty degrees can be eliminated by proper pre-exposure, it should appeal to us as worthy of incorporation, if possible, in our methods of study, even at the expense of time. It is more than likely that a little further study along this line may evolve a more readily applied technique.

Experiments.—The effects of pre-exposure on the results is due to the after image. A dark pre-exposure produces a light after image, while a light pre-exposure causes a dark after image. If the retina, therefore, is pre-exposed to a gray of the brightness of the

* They were the first also[20], [22] to demonstrate clearly the effect on the normal field in physiological studies, when proper pre-exposures are made and the surrounding field is of the brightness of the test object.

† The author has called attention in detail in several papers [6], [7] to defects in the perimeter. In addition to poor illumination, the test object is decidedly objectionable because it is usually counter sunk in a carrier of considerable size whose movements back and forth attract the patient's attention and prevent proper concentration on the test object. This is a real disadvantage when testing the average patient. The object carrier suggested by Ferree is very much larger and will be even more disturbing than that found on the ordinary perimeter.

As the proposed perimeter will necessarily become a commercial product it is exceedingly doubtful whether the proper standards as outlined by Ferree and Rand will even be approximately maintained. Zentmayer in his report before the American Ophthalmological Society, 1919,[24] on standardization of the colours used in perimetry, found that there was no uniformity in the pigment papers employed. If it is difficult to obtain uniformity in a matter so small as this, how much less likely will it be to obtain even an approximate uniformity in the proper selection of the grays required for each test object used. It would seem, therefore, that although pre-exposure and surrounding field are of sufficient importance to command our careful consideration, their practical application to every day perimetry is far from being an accomplished fact.

colour stimulus used, the results obtained must necessarily be more accurate than by our present system. The surrounding field should likewise be of the brightness of the stimulus to prevent contrast or mixing of colour.

There are many details to be worked out before laboratory methods can be so modified as to suit our purposes. One need not assume the rôle of a prophet, however, to forecast the important changes which may be incorporated in future methods of clinical study. They are:—(1) Perimetry will be largely practised on a tangent plane. (2) Light standardization will be a *sine qua non.* (3) The peripheral and the central field will be studied by a movable stimulus. (4) The stimulus will be moved by hand and not by an automatic device. (5) Pre-exposure and surrounding field will be equal to the brightness of the stimulus employed. (6) Light standardization, with photometric measurements made possible, will enable us to determine threshold values in disease, for any particular point in the field, and particularly in the central zone, which will help us to detect disease with greater accuracy in its incipiency, and at a time when therapeutic measures may be of real value.

While these changes will necessarily increase the amount of time required to study our cases, the advantage of being able to determine definitely the earliest evidence of disease, which our present methods frequently fail to uncover, will justify the time spent, and will relegate our so-called routine methods into the keeping of those who find perimetry requires too much time to practise.

Blind spot studies.—The methods employed in the study of Mariotte's blind spot are practically those which have been in use for some years past. In the matter of record, and for the purpose of reproducing and thereby verifying abnormal shapes and sizes of normal and abnormal blind spots, the following plan will lead to a better correlation of the changes which may be found.

1. Studies should be made on a tangent plane of a one metre radius.
2. The test object should subtend an angle of thirty minutes if central vision is approximately normal, about 6/6.
3. The illumination should be standard artificial daylight.
4. Care should be observed that the test object is moved back and forth from invisible to visible and *vice versa* until the boundary is definitely fixed. The points of examination should be close enough to eliminate any artefacts in the shape of sharp angles if they do not exist.
5. Findings should be verified and reproduced by the same or several investigators to be perfectly sure that the findings are correct.
6. When verified as correct they should be preserved in their original size and shapes by cutting out of paper, the same to be filed with the records of the case.

There has been so much diversity in the reports of the shapes of so-called normal blind spots that a plan, such as the one proposed and which the author has put into practice, will give us more accurate information than we have at present. It would be very interesting indeed to gather a collection of normal blind spots studied as outlined above by many investigators. In such a study reproduction is the essential element, and only those which can be verified several times should be regarded as suitable to be reported.

In the second part of our discussion, as we are dealing with principles and not with specific or individual cases, we can speak only in a general way of the types of study for which each method referred to has a special adaptability, and yields most accurate results, with consideration at the same time of the facility with which the examination can be made.

It is probably safe to say that the arc perimeter is best adapted to the outlining of normal or nearly normal form and colour fields. In my experience it has no other function in perimetry for which it is adapted. It is also my belief that a large part of this work can with equal facility be accomplished on some form of tangent screen. With this opinion many may have occasion to disagree. It is not gracious to disturb long accepted and prevalent beliefs, but; in the interests of progress, it is sometimes demanded. The above conclusion is the result of an honest conviction that the perimeter has been made to serve a purpose for which it is mechanically unsuited and that its misuse has brought to the front and developed the possibilities of the tangent screen which demands our careful consideration. We are prone to follow established lines of cleavage even though they may lead us to a fault, and it requires courage to approach by a more direct route. As the diamond drill now opens the treasures of the earth by a bold but direct path and has rendered older and slower methods of approach almost obsolete, so we, as physicians, should be ready to repudiate—if necessary—time-worn methods and traditions when they are shown to be fallacious, even though they served well their purpose in the past. The perimeter has a field in routine office studies, but in its present form a very limited one.

Routine studies of Mariotte's blind spot are most advantageously made on the hand campimeter at close range or on the stereo-campimeter, in either instance by means of binocular fixation when possible. The latter instrument is ideally adapted for this study as it is most accurate and fixation is easily obtained. In the absence of a stereo-campimeter, the hand campimeter is a very good substitute. The large tangent plane of a one metre radius may be employed in very slight enlargements, as the blind area is relatively increased thereby and may admit of easier study, and it should be employed in any analytic study of the blind spot. Some, indeed,

may prefer to use the large tangent screen at all times. It does the work well at a one metre radius within thirty degrees of the fixation point, but consumes more time than the smaller types. At a distance greater than one metre it is unsatisfactory. This is particularly true of colours and is due to the fact, as already pointed out, that the test object is too small at so great a distance to obtain full saturation of colours. The element of fatigue also enters as a factor.

Central field study, included within the forty degree circle, is the special function of one of the various types of the tangent screen. In this investigation the greatest freedom of approaching the defect is demanded. Which type of tangent plane to select is not wholly one of individual preference, although that is a determining factor. The extent of the scotoma, the inclusion or exclusion of the macular area in the defect, and the unilateral or bilateral involvement of the macula are phases which definitely decide the choice of the plane. Any or all of these changes can readily be made on the hand campimeter or on a plane with a radial distance from the eye of not more than thirty-three centimetres. The reasons for this limitation in distance will become apparent later.

To group them, however, to the best advantage for study the following is the classification which has given the author the most satisfactory results.

1. Any defect of the central field when the macula is intact and fixation is possible should be studied on some form of tangent plane. The character of the plane may be determined in part by the individual preference of the operator.

2. Paracentral defects which do not exceed in extent the range of the stereo-campimetric slate of Lloyd are best studied on this plane.

3. All unilateral defects within these same limits, if the fellow eye is normal, or at least able to fix, and the muscle balance is approximately normal, should also be studied on the stereo-campimeter.

4. Central and paracentral studies which require a larger field than that offered by Lloyd's stereo-campimeteric slate should be made on the hand campimeter, or a tangent screen of not more than thirty-three centimetre radius. This rule should be followed regardless of the size of the scotomata, if both maculae are included in the scotomatous areas, if the muscle balance is bad, or if fixation in the opposite eye is not possible because of visual disturbance.

5. For a careful analysis of the "important feature" so aptly referred to by Helmholtz, the Bjerrum screen at a one metre radius and with test objects, which subtend an angle of from thirty minutes to two degrees, is the instrument of choice.

When one eye is totally blind, squint or muscle imbalance of a marked degree is present, or when both maculae are involved and stereoscopic vision is not possible, "field taking" requires a special

technique. Under these conditions several methods have been proposed. Two only of these methods have seemed to me to be practical. The first is to make use of the patient's muscle sense in the following manner. The index finger of the patient's right hand is placed on the fixation point and the patient is instructed to look at the end of his finger. This can be done with much accuracy and with little wandering of the eye by the most illiterate patient, providing muscle sense has not been lost. In order to do this comfortably the distance of the campimeter from the eye should not be over thirty-three centimetres—a convenient reach for the average arm. One can proceed in this manner to outline a central scotoma with fair accuracy. The accompanying charts illustrate well the practicality of the method, as that taken on the campimeter by this method compares well with the one studied on the stereoscopic slate. If muscle sense is lost, as it often is in tabes, the method is impracticable and another may be substituted.

This second method is a modification of the one which the late Wendell Reber practised. Reber drew a cross in crayon on the blackboard and connected the ends by a curved line. The patient was instructed to look at the circle, and the central part of the cross was erased until only the peripheral ends were visible. With these four points as a fixation for the eye, the test object was passed back and forth between the points and the blind area was definitely determined. This method, of course, admits of error, as the gaze may be directed too far in any one direction. It, however, offers a fairly satisfactory solution of a difficult proposition.

The following method is suggested in order to reduce the percentage of error to a minimum. The patient is seated at a perimeter, the point of fixation being, of course, invisible. He is now instructed to look along the horizontal plane of the perimeter until the fixation point becomes visible. With the eye in this position the lamp of a luminous ophthalmoscope is now moved along the arm of the perimeter until the corneal reflex of the light rests in the pupillary centre and the degree is noted on the perimeter. (This method is similar to that of measuring the angle of squint on a perimeter.) If the right eye, for example, were moved to the right fifteen degrees, the nasal limit of the scotoma would be fifteen degrees to the nasal side of the fixation point. These measurements are taken in the four cardinal directions of the eye. Four white markers are now placed on the campimeter as determined by the luminous points on the perimeter and the definite outline of the scotoma can be obtained with little chance for error. The four points now used for fixation are accurately located, and the scotoma can be definitely outlined and the peripheral field may be studied as well. This perhaps is painstaking but accurate.

Fixation in bilateral central scotoma, I have no doubt, has caused each one of you much thought and worry, and if anyone has a simpler and less arduous method to propose in these troublesome cases, we will all be indebted to the gentleman who will furnish it. Many suggestions have been made, including those of Hess, Walker, and others, but unfortunately they are not practical for routine office use.

What might have served as an appropriate introduction will apply equally well in closing. The title of the paper in a way is misleading. Modern methods are not new. They are simply an adaptation of old principles to more recent conceptions—a choice in other words of specific instruments for particular tasks. What really is new is a developing consciousness in the profession that perimetry is an essential part of ophthalmology to be employed in the daily routine of office practice, and not simply an interesting bit of investigation to be practised in one's leisure moments.

Like photography, perimetry has passed from the shadow or silhouette phase to one of topography—from a study of outlines and boundaries to feature studies. This has necessitated a change in methods and a higher specialization of instruments. How much we have gained in knowledge of many obscure conditions by methods of careful analysis is well illustrated in glaucoma. Rönne's steps, Bjerrum's sign, and the colour changes beautifully differentiate between the ascending atrophy in glaucoma and the descending type of primary optic atrophy. This is but one of the refinements made possible by modern campimetry.

In short, newer methods in perimetry consist in the choice of the right instrument for a definite task, feature studies of the central zone as well as tracing the boundary, and the use of the tangent plane as the instrument of choice with the perimeter as a necessary adjunct.

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A FEW NOTES REGARDING THE DETERMINATION OF THE LIMITS OF THE VISUAL FIELD*

BY

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THE method indicated by Bjerrum in 1889 of determining the limits of and defects in the visual field is rightly used in cases where the object is to trace the more delicate workings of the retina.

The principles indicated by him have been further worked out by his pupils, particularly by Rönne in Copenhagen, and subjected to wide practical tests. Shortly after the publication, oculists, especially in England, adopted this method, as witness the number of apparatus constructed there for the accurate definition of the visual field and scotomata, and the introduction of a quantitative method of accurately arriving at this definition (Traquair).

(1) The fixation point.

Nowadays, the black curtain and the white and coloured discs of different sizes, belong to the usual outfit of every oculist. Still there are some drawbacks connected with this so widely adopted method, which in the determination of the visual field play a certain rôle. This matter demands a great amount of attention on the part of the examiner as well as that of the patient, and of the latter also a power of endurance demanding much of his often already reduced will power. It is, therefore, necessary to remove as far as possible everything which can divert the patient's attention,

* Read at the Oxford Ophthalmological Congress, on July 15, 1920.

or may lead him astray. The ideal method is thus the one whereby all the senses of the patient, except the eye, receive as little irritation as possible, and whereby the eye does not detect anything else than :

(2) The object which moves in the periphery, and regarding which the patient must promptly indicate whether it appears or disappears, and,

(3) The background on which fixation point and moving object stand out clearly.

On these three points I will now make a few comments.

Various oculists have tried to attain their object of avoiding all unnecessary irritation to the patient, by making themselves as far as possible invisible, and, dressed in black clothes and wearing black gloves, taking up a position behind a sort of screen, from which shelter they move little objects, attached to a long stick, to and fro in front of the curtain. This is really a good method of keeping disturbing influences away from the patient, although it has been asserted that all these precautions must make the patient somewhat drowsy, a verdict however that is by no means confirmed by experience. On the contrary one perceives that a patient whose attention is centred solely on the task imposed upon him—a task that is often very difficult for him—gladly dispenses with all disturbing outside influences, by whichever of his senses these may be brought to his consciousness. By the ***modus operandi*** described above, a portion of the unnecessary retinal irritants is excluded, but another part still remains, as for instance, the whole apparatus that must be erected near the patient (and which casts a shadow on the screen, also the moving stick, and then the signs that must be made on the screen, be these almost invisible, to indicate where the patient has seen the object appear or disappear. Moreover, if the operator stands very much to one side, he himself cannot see very well whether the patient keeps the eye, which is partly hidden behind the nose, quite still. In order to avoid these disadvantages—which for brevity's sake cannot very well be gone into in greater detail—one can span a large black cloth of dull woollen material,* and have a small opening made about 4 ft. 4 in. from the ground, wherein a fixation object is attached. By using a revolving chair and a chin support that can be raised or lowered, one can be assured that the eyes are always about 4 ft. 4 in. above the ground. On the side of the screen that is turned to the light, nothing is visible but the object on which the gaze must be fixed. On the other side, however, a division in circles and radii is painted. The circles are so far from each other

* The cloth I use is 4 feet by 6 feet. He who has more space available would do well to take a larger cloth (as also indicated by Bjerrum), and let the patient sit in front, about 6 feet away, thus double the distance of my patients.

that the distance between any two successive circles measures exactly 1°, as seen from the point of observation, which is about 40 in. from the screen.

The radii are drawn at distances of 5° (or 7.5°) from each other. The observer has eight or ten small (button-hole stitched) holes, a few millimetres in diameter, made in the cloth at about the height of his own eyes, so that he can see the patient from any of those points behind the curtain. These holes, however, are practically invisible to the patient, especially if the illumination behind the screen is weaker than it is in front, which usually is the case.

For objects, one uses coloured steel balls of 2, 3, 5, 7, and 10 millimetres diameter, which can be caused to make all the required movements by means of a small hand electro-magnet moved in all directions behind the screen. He who possesses a Hirschberg magnet with the accompanying accumulator will find that it answers very well for this purpose.

If there is electric light in the house (continuous current) one can, by inserting a wire or lamp resistance, connect up to a 6 or 8 volt magnet. If, however, one has only an alternating current, then one must get an accumulator of 6 or 8 volts, with a suitable magnet, not too heavy, and easy to handle.

The mapping of the visual field, in front of the screen, is now quite simple. Through the small holes in the screen one controls the patient, at the same time moving the magnet (and also the steel ball that is in front) in the same manner to and fro as one does the stick generally used for defining the visual field. As soon as the patient states that he sees the ball, one makes a sign with white or coloured chalk at the back of the screen at the place where the ball was when he made that assertion. The marks which one has made are combined later, when the whole examination is concluded, on a suitable plan, according with the divisions on the screen.

The advantages of this campimetrical manner of investigating the visual field are, in my opinion, the following:

(1) Everything that is not an attribute to the testing of the visual field is eliminated.

(2) It is not necessary to make any lines or other signs at the front of the screen, so that the patient is unable later on to refer to his own statements, which, voluntarily or involuntarily, he often does.

(3) The even diffusion of light on the screen is greatly improved by the installation above described, which, especially with patients with a disordered sense of light, is a great advantage.

(4) It is easy with artificial light—although one does not use this by preference—to examine the visual field by a frosted electric lamp placed in a slanting direction above the patient, so that no shadow is thrown on the screen.

My final remarks treat of the manner in which the patient's gaze is kept in a certain direction. First of all, I must point out that in the fixing of the gaze, the eye, as is well known, even where the patient exerts himself to the utmost, is never entirely still, but constantly makes small deviations of about 5′ in various directions. This physiological nystagmus, which cannot be suppressed, does not, of course, play any rôle in the determination of the limits of the visual field in which mistakes of a few degrees are often made, and, therefore, need not be taken into consideration.

The gaze is usually arrested by a fixation point, a white dot, or a black dot in the centre of a slightly larger white patch, both of which are excellent means of bringing the eye into a position of rest for people with a good central visual acuity. If, however, there are central scotomata, this method will leave us in the lurch, and then one can help oneself in different ways, for instance, by letting the patient look at his own finger, which he lays on the middle of a peri- or campimeter. This, however, is only possible when those instruments are very near, and, therefore, not by the method of Bjerrum, apart from other noticeable disadvantages which are connected with this method.

If only one eye has a defective visual acuity, then the other one can serve to indicate the direction of the gaze of the first one, to which end various methods are available; for instance, with complemental colours (Schlösser) or with the aid of the stereoscope (Haitz), or with a projected centre (Walker), all methods into which I need go no further, as none of them is of any assistance if both eyes are defective.

If there is an absolute or relative central scotoma, then nothing else remains to be done but to enlarge the fixation point to a more or less extensive fixation field, and to request the patient to gaze at the centre of it. By adopting this long used and tested method, more of the retinal elements are of course irritated, and if the patch is big enough, perhaps also some that are not affected. The patient hereby gets, in any case, an idea of the direction in which he must look. A white ring with a black centre, however, is better than a patch, especially as one can make tests in the centre of this ring, just as well as outside of it. Here again one has the same contra-distinction of the white or coloured object with which one works in contrast with the dark background, whilst this contra-distinction is a different one on the white central fixation area.

Central scotomata, especially small ones, should never be sought for in any other way than this, because the difference in the value of the white, between an object and a white or black background is very great, so that the patient gets quite a different impression of a moving object that stands out against the white centre to that obtained when the same object is seen in front of the black background.

If one wants to use this fixation of the centre point of a ring more universally, then one must know with what degree of accuracy this fixation is performed. As one wants to apply the method indicated chiefly to patients in whom one presumes that a central scotoma is present, it will be useful, if possible, to imitate somewhat the vision of such sufferers, to learn experimentally how and what they perceive.

An observer with normal eyes can do this by going for a short period into the dark, after which the well-known central physiological scotoma of about 4° shows itself, through which he will not be able to perceive a weak light in the centre.

One has prepared the following test beforehand: A ring covered with luminous paint is so attached that the inside of the ring can be seen from the place of the observer at an angle of 4°. In the middle of this ring is an instantaneous shutter of a photographic apparatus, which can easily be opened and closed by the observer from his position. Behind the photographic shutter a Nernst lamp is placed, the vertical wire of which goes exactly through the middle of the round opening in the apparatus and thus also through the centre of the luminous ring. After the appearance of the central physiological scotoma the observer begins as accurately as possible to fix the centre of the faintly luminous ring, and when he thinks that his gaze is correctly directed on the centre, the instantaneous shutter is opened for a fraction of a second, for such a short period of time in fact, that in the meantime not the slightest movement of the eye is possible. The irritation of the light of the glowing Nernst lamp has, nevertheless, worked long enough in this short period to produce a sharp after image and this after image is now drawn on the piece of paper, placed vertically, which had been prepared in advance, and in the middle of which a black fixation point had been indicated. As the distance from the eye of the observer to the paper is known, it is possible to calculate from the point where the copies are drawn, how far the eye has fixed outside the centre of the luminous ring, and it now appears that this deviation—out of an average of twenty tests—has never been greater than 1° 15′ in any direction.

Of course, one cannot immediately compare the results attained with artificially induced central scotoma, with the fixation of patients who are suffering from pathological scotomata. But experience with a greater number of patients has taught me that people with a bigger or smaller central scotoma, whatever its cause, can keep the gaze fixed on the centre of a white ring. Deviations of 1° to 2°, however, in the direction of the gaze, have practically no influence on the definition of the limits of the visual field, or of scotomata in that field.

In order to compare the probability of the deductions drawn from

the preceding reasoning with the reality, it has been necessary to examine a normal visual field, once with a small white central fixation point, and then with a fixation ring. The result of this examination with a small coloured ball made on the above-mentioned screen is that there is no more difference between the two tests than between two successive tests with a central fixation point.

For normal observers, however, fixation of the centre of a ring is more difficult than fixation in the ordinary manner, so that the first method should only be used with patients having central scotomata, hemianopsia, etc., as one can also hold the gaze fairly well through part of a ring—the rings can easily be made visible on the above screen. This is done as follows: Small aluminium plates, which have been made slightly globular, are attached to the centre of the screen by means of a small bolt on the back, and a nut. A white ring of a few millimetres breadth is painted in the periphery of these plates, which must be of different diameter, so that they can be seen at different angles, whilst, again, the centre of the plate is either painted black or covered with black material. Owing to the slightly globular inclination to the front, the balls run easily on the discs, the centre of which can be tested also in this manner.

DISCUSSION ON PERIMETRIC METHODS

Professor Van der Hoeve (Leyden), wished to congratulate Dr. Peter on the very accurate and scientific way in which he had treated the subject.

It was the duty of the ophthalmic practitioner to carry out his perimetric methods as rapidly as was consistent with accuracy, for it must always be borne in mind that hurry and exact perimetric examination do not agree. Perhaps it would be better to make no perimetric examination at all than to do it hurriedly; haste might cause the observer to overlook many valuable scotomata. Exact perimetric examination must occupy a deal of time, more time than can properly be spared in the hurly-burly of a polyclinic; it asks two things: time and patience on both sides, i.e., on that of the patient and on that of the doctor. Therefore we have to make our methods as good as possible for quick examination and take advantage of as much assistance as will enable us to carry it out at our ease.

A second point which must be considered is the size of the object. We should not continue to diminish the size of the object and increase the distance of the patient from the screen as otherwise we shall be more and more troubled with physiological scotomata.

The warning of von Hess that in some of our modern methods of perimetry, the image of the object on the retina has a much smaller diameter than the vessels must be borne in mind.

Neither the radial, nor the concentric moving of the object, nor yet the moving perpendicular to the nerve fibres is the only rational method. If there is one rational method of moving the object to the exclusion of all others, it is that of moving the object perpendicularly to the boundaries of the area we wish to map out, that is to say to the periphery and boundaries of the scotomata.

To be able to carry this out we must first find out where the scotoma area is and then change the direction according to the circumstances.

To find out every scotoma, without omission of a single one, it is absolutely necessary to touch each part of the visual field with our object and it is exactly the same whichever way we do this, either by horizontal, oblique, radial, or concentric moving or by moving perpendicularly to the nerve fibres, or even by moving quite irregularly if only we ramble all over the visual field and touch every point of it. This is an immense task, but happily for us, most of the scotomata, at least the most important, may be found in the central part of the visual field, so we may examine this as carefully as possible and do the much larger periphery rather more rapidly. In doing so we must, however, not confine ourselves to the papillo-macular field only, but exceed this region in every direction.

Perhaps the following is the best method: After carefully mapping out the blind spot we encircle this in two or three circles, the first very close to the blind spot, the others at some distance and we then ramble with vertical movements all over a region from about 15° on either side of the fixation point and the same distance vertically,

In this way we are sure to find out every central and paracentral scotoma for we cross continually the place where Bjerrum's arcuate scotoma may be found and, moreover, we touch several times the projection of the raphe retinae.

The raphe retinae is a very important region because it is here that Bjerrum's scotoma may begin. He agreed fully with Lt.-Col. Elliot that Seidel's sign (the wing-shaped enlargement of the blind spot) is a very important one for the early diagnosis of glaucoma, but Bjerrum's scotoma may begin at other spots too, for he had seen many patients where the scotoma first appeared at the raphe retinae, indeed, in some cases Bjerrum's arcuate scotoma was complete except for the spot touching the blind spot so that we had a negative Seidel's sign.

Bjerrum's scotoma never, or hardly ever begins in its whole extent

all at once, it may begin at every point of the bow and extend from there. It may even start at another point and the two scotomata join together. The scotoma may be absolute or relative, or have absolute and relative parts.

Lastly, he wished to utter a warning against the law laid down by Igersheimer, that in every scotoma caused by disease of the optic nerve, and also by glaucoma, a bridge is present between the scotoma and the blind spot.

Every ophthalmologist knows how often in retro-bulbar neuritis the central scotoma, without bridge to the blind spot, is the principal sign.

Dr. A. H. H. Sinclair (Edinburgh) said it gave him great pleasure to congratulate Dr. Peter upon his paper, which was a most comprehensive statement on the modern aspects of the subject. It expressed fully and adequately, and in a most interesting way many of the things he had thought of in regard to the use of the screen test and the perimeter. He was disposed to say the perimeter should not be ruthlessly put on one side: it was an instrument which, as a rule, was very badly made. He thought perimeters should be made free from mechanical devices for moving the test object: this should be moved by hand, and the instrument should be limited in employment to the cases for which it was suited, to map out absolute scotomata and the limits of the visual field. It should be placed in front of a black screen when used. When the test was for white, the use of a small test object was important, because if one larger than was necessary to stimulate vision at the periphery of the field was used, defects might readily be missed. For colour testings the object should be larger, as Dr. Peter had said. He would not enlarge upon that.

With regard to the campimeter and screen, he had no practical experience of Dr. Peter's instrument, but had used the Bjerrum screen for twenty years. In his consulting room he used a 1-metre screen, while for more delicate work he preferred a 2-metre screen. He thought that his practice in this matter would be supported by others who had dealt with the more difficult work in connection with tracing scotomata of relative type. Dr. Walker, in Boston, U.S.A., had used a large screen with a very small test-object. Dr. Traquair had carried out his work with the large screen. The speaker had watched Dr. Traquair's work in Edinburgh and valued it very highly. The screen or campimeter was of value for the central zones of the field, but not for the periphery. Within a zone of 30° it was incomparably more valuable than the perimeter, especially for the detection of early relative defects, and workers who wished to have a real knowledge of the functional state of the central portion of the field should use a campimeter or screen. The

Peter's campimeter he had not used, but he hoped to become familiar with it in practice, for, as far as he could judge, it appeared to be a useful instrument.

The Bjerrum screen was intended to be used with a small white test-object; the colour tests made by it were not so satisfactory, but were also of great value. For white, the size of the test-object could, if properly used, be very much reduced without leading to errors in observation. The test-object should be moved from the blind area to the seeing area, and also in the reverse direction. It should be moved in a concentric or circular way as well as radially. In fact, the freedom of movement which is gained by holding the test-object on a fine dull black rod, and moving it by hand, is a factor of primary importance in securing the closest approximation possible in the correct mapping out of a relative scotoma.

The value of the perimeter and screen test, and of all tests applied to the field of vision in addition to their value to the ophthalmic surgeon in glaucoma and other diseases of the eye, lay largely in the relationship of the findings to general medicine. This aspect of the matter was not yet sufficiently realized. Physicians and surgeons did take patients' fields with the perimeter, but did not know or sufficiently value what could be done with the aid of the finer methods. The screen test in certain cases gave information of the utmost value. It would be well if ophthalmic surgeons could impress upon students and doctors, especially on those interested in neurology, the value of the more refined methods of field examination. He regretted that when recently in Boston, he did not see Dr. Walker, but was much interested there to see something of the work which had been done, and was going on, and some of the apparatus in use. He had had the privilege of meeting Professor Cushing, and was greatly interested to see what importance that authority on brain surgery placed on the results of an expert examination of the field of vision in his patients. The great value of the screen test and perimeter in diagnosis is still becoming more and more evident. It was of the utmost importance to get at the very earliest signs in diseased conditions, and it was in the matter of early diagnosis that the value of the tests, now under consideration, should be emphasised. It had been of very great interest to him to hear Dr. Peter's paper.

Professor Harvey Cushing (Boston, U.S.A.) said, in reply to the Master's invitation to him to speak, that he felt somewhat humiliated to be found here taking notes, but there remained nothing for him but to confess his guilt in that matter.

He attended there on that occasion to see what an Ophthalmological Society looked like, expecting to stay only a moment, as he

had other duties elsewhere; yet he found himself so greatly interested that he had remained all the morning. He was, perhaps, more interested in a discussion on the "humanities" which was proceeding when he arrived, something which, he was sure, would not take place in an American Ophthalmological Society, because there they did not know the difference between Latin and Greek! And he had listened with tremendous interest to the author's report of his group of cases, which to most, he thought, meant a new syndrome, and it constituted a very important contribution to medicine. He had seen some of these cases, and freely confessed that he did not know what they were. He would now go home, and spend his declining days going through the asylums over there —he hoped merely as an observer of patients; and, as someone had hinted, he might even find some examples in the United States Senate of mental disturbance in some degree.

The whole question of perimetry was of more interest to those who did not pretend to be ophthalmologists than might be imagined. The whole story of instruments of precision was a story which went from the early days of medicine. All were striving to produce instruments of precision. It was not so very long ago that a similar discussion was taking place among a body of physicians regarding different kinds of thermometers, or, possibly, different kinds of watches, for Fleury was endeavouring to count the pulse by simply the swing of the pendulum, so that he came to speak of a pulse as a "10-inch" or a "12-inch" pulse; he got a pendulum to swing synchronously with the pulse. The introduction of these instruments meant the taking of more and more time for the working of a clinic; the calorimeter might take a morning for the taking of an observation, and similarly with the electro-cardiograph. The perimeter was an old instrument, and in many clinics, he grieved to say, it was used very little, but he supposed that to everyone who was devoted to patients with intracranial disorders, very largely cases of tumour, the perimeter became a most important adjunct, not only as a means of diagnosis, but also for determining the advance or the subsidence of the disease. That was particularly the case now that the surgeon had invaded the field of pituitary tumours. Studies such as had been put before this meeting therefore became of vital importance to those engaged in this work.

What were they to do? Must they have an expert ophthalmologist, who had had a special training in perimetry, to carry out these procedures? Or must the taking of these observations be simplified in such a way that a junior in the clinic could make sufficiently reliable observations. Perimetry was difficult, it required much interpretation, and the patient's interpretation required interpreting. Also the patient became fatigued, and hence

much judgment on the part of the observer was called for. Having made many such observations he knew how difficult they were. He also knew how they were misled into writing a very unfortunate paper many years ago, in which they tried to talk about the interlacing of colour fields. And though he felt sorry they put that paper out as a means of diagnosing brain tumours before choked disc appeared, and before there was swelling of the papilla, nevertheless it did good, because it led to many practitioners using the perimeter; hence, by the mistake of the authors of that paper, the instrument was again used in many clinics where it had fallen into disuse. To-day, certainly it must be regarded as an absolute necessity. And it could not remain an instrument to be used solely by ophthalmologists, any more than it could be said that no one except certain specialists must use the stethoscope. Hence it was obligatory on ophthalmic surgeons to find some standard on which all could agree as an instrument good enough for all, though it would not necessarily be "fool-proof," for no instrument in regard to which interpretations were necessary could be fool-proof. The matters which this meeting had been discussing and which interested experts in this line very greatly, such as the detection of scotomata, the enlargement of the blind spot, and cases of glaucoma and retro-bulbar neuritis—whatever that term might mean—he did not pretend to know very much about. But when it came to a matter of changes in the periphery of the field, brain surgeons and others did know something about that, it was what they were chiefly interested in. It was a good many years ago that they began to take, in a routine way, the fields of every patient who came in and was even suspected to have a brain tumour, every case in which there were pressure manifestations. Some of the men on whom this work devolved became very expert at it. Walker, for instance, was a mathematical genius of the Helmholtzian order: he took to this work, and, using largely the Bjerrum screen, detected very early pressure changes, especially changes in the chiasma due to pituitary lesions. Those observations helped him, the speaker, and others enormously in their work. Peripheral changes in the fields should be known, not only for cases of pituitary disorders, but for asylum cases. He would mention, as an instance, the temporal lobe. His hearers knew how far forward the visual pathway went in the temporal lobe, namely, to the anterior chiasma, and curved round the anterior horn of the ventricles, so that any lesion in the temporal lobe would produce a homonymous defect in the field. Curiously, for a reason he did not know, that defect in the field always came first on the same side as the lesion, and it might advance to a quadrangular defect before any defect came into the opposite field at all. There might be a very minute lesion, a stab wound, perhaps, in the temporal

lobe, and that would cause a homonymous defect, which passed in almost to the macular region, and that would not be detected unless one examined every 15° of periphery. Possibly one might find a defect passing in the field of each eye to the macula, and close study was required. In the case of temporal lobe tumours, one could tell by bilateral changes in the field whether the tumour was high or low, because these paths showed the same kind of course through the brain: the geniculo-calcarine pathway as in the geniculate region. Therefore it was necessary that there should be some form of field-taking which was applicable to all patients, one which could be used whether the patient was sitting or was in bed, and which was capable of being employed by those who had not the great skill which was the possession of the ophthalmologist, and which some men might attain to in general clinics. What he hoped was that this meeting, as a result of this discussion, might agree upon something which could be passed on to those interested in ophthalmology, but who in the matter of practice stood only on the threshold of the speciality.

Dr. S. Holth (Christiania) said: I have found the Bjerrum tangent plane method most useful for testing defects in the central visual field. When I began to test this method more than 25 years ago my results, however, were disturbed by the "staring blindness," first observed on unmoved peripheral objects by Troxler, 1802; the cause of this was that I moved the small white objects too slowly, then they disappeared in spots where there did not exist any scotoma. On the other hand, when the observer moves the object too fast he may pass over a real scotoma; he is between Scylla and Charybdis.*

For the testing of the outer limits the perimeter is indispensable. The ordinary arc models (also in the form of the "hand perimeter" of Schweigger) are too cumbersome on travels and at the sick-bed; they are too costly for the general practitioner. For these purposes I have, many years ago, constructed an instrument which has not been demonstrated outside Norway before to-day; it was destined for demonstration at the XIIth Ophthalmological Congress at St. Petersburg, 1914, under the name of "The chord perimeter," and was described in the *Transactions* of the Congress, Vol. I., p. 123-129; an account of it was printed in the *Ophthalmoscope*, 1915, p. 14.

My first communication did not point out exactly enough the three different and very useful applications of the instrument:

* S. Holth, "Det. normale synsorgans stirreblonhed," Christiania, 1896.

(*a*) as an ordinary perimeter, (*b*) as a very sensitive test for central scotoma, and (*c*) as centimetre-dioptre measure in refracting work.

I find it, therefore, necessary to give a new description accompanied by one of the old illustrations and two new ones.

(*a*) *Perimeter.*—The principle is as follows: The graduation of the two perimetric circle quadrants are projected on the corresponding chords (Fig. 1).

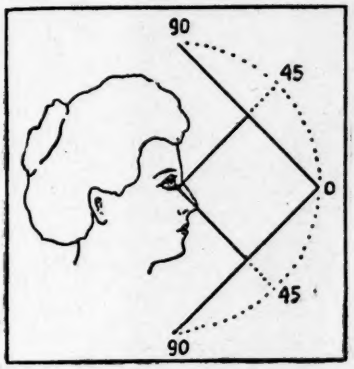

Fig. 1.

Two rules, 27·5 centimetre long, are connected at a right angle by a joint, corresponding to the fixation point of a perimeter; the chord graduation occupies 25 centimetres (Fig. 2). Two metal sticks attached to the rules when at right angles have their connecting point in the centre of the half circle (Fig. 1).

The object holder (see Fig. 2) kept in a deep furrow in one of the rules, is a thin blackened steel stick provided with a white bead of two millimetres diameter on one end and on the other end a cube of vulcanised black rubber, on which four sides have a celluloid disc (white, blue, red, and green) of 7·5 millimetre diameter inlaid.

I have on purpose not provided the chord perimeter with any graduated disc for the meridian positions. The horizontal and the vertical meridian you take exactly by eye measure; for the oblique meridians the error limit is under 2 degrees, which is of no account in clinical perimetry. In many cases it is sufficient according to

Haab to test the vertical, the horizontal and the meridians 45° between them = in all 8 directions. It is, however, as easy to test in all the meridians corresponding to the ciphers of the clock dial = 12 directions; equally in the nasal meridians just above and below the horizontal meridian — important in glaucoma.

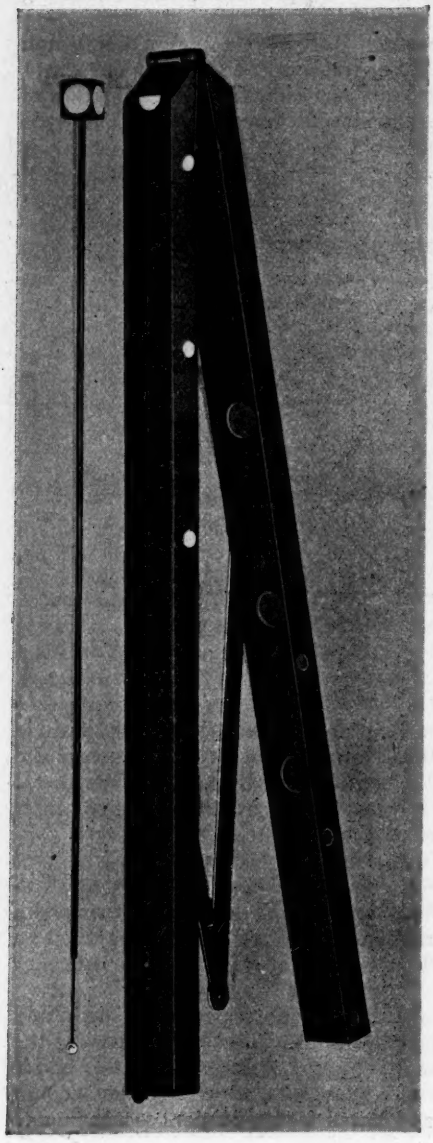

Fig. 2.

The chord perimeter nearly folded together after use; and the object holder. Reduced in size from 27.5 to 15.5 centimetre. (On the rule to the right the numbers of the perimetrical graduations by a mistake are not reproduced.)

The outer limits for colours are always taken by the celluloid discs, often also the limits for white; but the white limits may also be tested with the white bead which always is seen in the whole normal visual field. Mariotte's spot and other absolute scotomas are also tested with the white bead. I have tested in retinitis pigmentosa beginning a paracentral ring scotoma of 3-10° extent as exactly in this manner as on a large arc perimeter.

(b) *Central scotoma test.*—In order to detect central scotoma in intoxication amblyopia and retro-bulbar neuritis I have placed on the outer sides of the rules groups of three identical celluloid discs (Figs. 2 and 3) in pink,

red, and white (also in green and blue, which, however, are superfluous). When the patient's eye fixes the middle of the three red or pink discs in horizontal position, the colour in the nasal disc is seen distinctly, in the central disc less distinctly, and in the temporal disc obscured, changed or not at all; when the three discs are in vertical position and the middle one fixed, the colour in this is less distinct than in the two others. This comparing three-spot-test was formerly placed in a separate instrument (*Annales d'Oculistique*, 1908, Vol. CXL, p. 169-175). This method should not be considered as a mere "rough and ready test"; it is true that the test is ready; it is not, however, a rough one—it is really a very delicate and sensitive test. By means of my three-spot-test in pink I have detected many cases of beginning tobacco or alcohol amblyopia, while the vision was still between 5/6 and 5/10. I want also to remind you that the same test has enabled me to detect central scotoma in protracted uveitis and in beginning sympathetic ophthalmia (*loc. cit.* and *Bulletins et Mémoires de la Société française d'Ophtalmologie*," Vol. XXVI, 1909, p. 308-309).

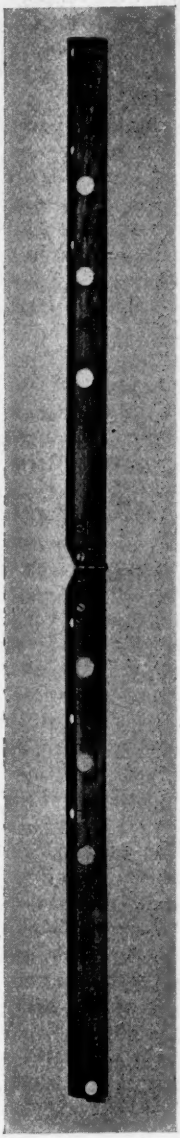

FIG. 3.

The two rules of the chord perimeter are straightened out and fixed at the joint forming a single rule divided into centimetres and dioptres (from 2.0 D to 20.0 D). Reduced in size from 55 centimetres to 15.8 centimetres).

(c) *Centimetre and dioptre measure.*—The two rules of the chord perimeter can be straightened in the central joint and by means of the metal sticks be fixed and converted into a single rule of 55 centimetres, which has also a dioptre graduation from 2.0 D to 20.0 D. Fig. 3.

The two first models of the chord perimeter of 1909 (black rubber or aluminium), which I now show you, cannot be straightened; they have no dioptre graduations and they were too expensive.

The actual wooden model can be used in the oculist's office as a very recommendable central scotoma test and as a dioptre rule in refracting work. By the sick bed and on travels it is more convenient for perimetry than ordinary perimeters. The general practitioner needs no other perimeter.

The instrument will be made by John Weiss and Son, Ltd., 287, Oxford Street, London, W.

Mr. E. H. E. Stack (Bristol) said that practically all the points he had intended to bring forward when he intimated he would speak had already been dealt with by speakers. He therefore would be content with emphasising one point, namely, the importance and value of having a moving disc instead of a fixed one for ordinary perimetry, also the necessity of working from the blind into the seeing area, as well as in the reverse direction.

Another little practical point, which he had found useful in out-patient clinics, was what he called the four or five-point perimetry. What he meant was that the sister, or whoever was helping him in the clinic, was instructed in many of the cases to take a very short perimetry in four directions only—above, below, outside, and inside, or perhaps two on the inside, and in that way he had sometimes found cases which needed a more detailed perimetry. He did not want to emphasise too much this time-saving method, but it enabled cases to be discovered which without that simple routine might be missed.

Lieut.-Colonel R. H. Elliot (London) wished to confine his remarks to glaucoma. Seven years ago, when he was first interested in Seidel's sign, he was unable to find a single instrument maker in London who could supply a Bjerrum's screen. That was evidence of the small interest then taken in the subject.

Seidel had described a pointed enlargement of the blind spot, which he stated could be found before any other sign of glaucoma was present. It was while studying glaucoma cases for this sign that the speaker evolved his present scotometer. Scotometry is of value in glaucoma in three ways: (1) in the diagnosis of very early cases; (2) in the study of the progress of a case; and (3) in estimating the value of an operation or of a course of treatment. In all these respects his scotometer had proved of the utmost value. He had never claimed for it that it was an instrument for laboratory research, though personally he believed it could easily be made such. But he had brought it forward for the help of the busy practitioner. It combined three principles: (1) Priestley Smith's circular method, as opposed to the radial method; (2) Bjerrum's enlargement of the scotoma; and (3) the methodical examination of the field at distances of 1° from the centre out to the 26° circle. He wished at the same time to insist on the importance of fixation of the head, in such a way that the eye remained throughout the examination at the centre of the system of circles under examination. If this were done, the mechanical attributes of the instrument insured the marking out with mathematical accuracy of the same portion of the field each time a circle was taken; the field could thus be accurately delimited out to the 26° by 26 rapid and precise observations, whereas, by working along the various meridians, from

or toward the centre, at degree intervals, 360 observations would be required, and that portion of the chart which lay within 5° or even 10° of the centre would be reduced to chaos. Despite all that others may say to the contrary, he regarded Bjerrum's principle of enlargement of the scotomata as of the greatest possible importance. It made work easy and accurate.

Then, with regard to his own contribution to the principles of this scotometer, viz., the methodical examination of the field at degree intervals from the centre out to 26°. It had from the first seemed to him unreasonable that the enlarged blind spot should always end in pointed extremities, as Seidel said it did. If this enlargement was due to the damage of the optic nerve fibres, as they flowed over the sharp scleral edge of the foramen, it was to be expected that the resulting scotoma would be frayed out into a number of points, owing to the fact that certain nerve bundles would be more damaged than others. Whether this were right or wrong in theory, he had found from the start that in cases, in which there was reason to believe that the nerve fibres were damaged at the disc edge—whether in glaucoma or otherwise—the enlarged blind spot showed a jagged edge, either upwards, or downwards, or both.

It had been suggested that this was an artefact. He would reply that, even if that were partly true, and he did not admit it, it still remained a sign that enabled one to diagnose injury to the nerve fibres at the edge of the disc. This had been proved by the experience of a large number of other surgeons who had confirmed his (the speaker's) findings. If it were asked, why this method should give evidence of this form of damage, when other methods failed to do so, he would reply that the direction of the damaged fibres is a circular one, around the centre of the retina; in using a rotating scotometer, one was *following the path of the damaged fibres*, and it is in the distribution of the damaged fibres that the jagged appearance of the scotoma finds its explanation; it is much more difficult to delineate a scotoma, when one passes across its narrowest measurement, than when one travels along the path of its greatest dimension.

With regard to the forms assumed by these blind-spot scotomata: one might find a typically enlarged blind spot with the edges jagged throughout its whole breadth, both above and below; again, one might find a single narrow arc-like belt of relative or absolute scotoma, continued along one or two degree circles only; or the blind spot might show little or nothing abnormal, and yet at some distant part of the periphery a commencing relative or absolute scotoma could be mapped out with this scotometer. Still other varieties could be found. He believed that the cause was the same in all, namely injury to nerve fibres at the edge of the disc. Why

then these marked differences? The answer lay in anatomical peculiarities of two distinct kinds, viz., (1) in the method of distribution of the nerve fibre bundles as they pass out of the papilla, and (2) in ill-understood physical variations of the scleral edge, which determined a patchy yielding of its circumference, and a correspondingly patchy lesion of the neighbouring nerve fibres.

With every deference for the opinion of others, he believed that in early cases the enlargement of the blind spot in glaucoma could be mapped out for all clinical purposes, by the use of small objects (grey if necessary) without resorting to the use of colours at all. Later, when vision was poor, larger objects (discs of white blotting paper) could be used on his scotometer, by the well-known method of Priestley Smith.

In using his scotometer, it was open to the examiner to travel in whatever way his fancy dictated, whether always in one forward direction, or back and forth, from blind into seeing, or from seeing into blind. He thought they would find that the scotomata would be most exaggerated, if they adopted the second of those methods (from blind into seeing), but the differences would only be small in any case, and would rarely exceed two or three degrees.

He cordially agreed with Priestley Smith, that the ordinary (33 cm. radius) perimeter was of great value in marking out the rough outlines of a field, in glaucoma cases, and that when the concentric method was used it would very often indeed show that valuable and too little elicited sign, Rönne's step.

In closing he paid a warm tribute to Dr. Peter's work in connection with perimetry, which had been of great value to ophthalmic surgery and medicine.

Dr. A. Maitland Ramsay (Glasgow) wished to join with other speakers in thanking Dr. Peter for his excellent paper. That gentleman had treated the subject so exhaustively that he, the speaker, did not feel there was anything useful that he could add to the discussion. Whatever instrument or method employed, he thought it would be agreed that patience and thoroughness on the part of the examiner were necessary in order to get accurate results.

He would like to say a word as to the elongation of the blind spot which was sometimes met with in association with sympathetic irritation. That observation was described in the January number of the *Ophthalmic Review*, 1906, by Dr. Sutherland and himself. Dr. Sutherland made the observation in a case of pronounced sympathetic irritation, and the value of the observation depended on the fact that after the injured eye had been removed the shape of the blind spot again became normal. Since then, he had himself come to place great value on the examination of the

blind spot in all cases of sympathetic trouble, and had found Dr. Peter's campimeter of the greatest value in enabling him to do this accurately and quickly. When he found that spindle-shaped enlargement of the blind spot, present in sympathetic irritation, he knew he must enucleate without delay, whereas if it were absent he felt justified in holding his hand.

Major A. E. J. Lister, I.M.S. said he, like the last speaker, had come unprepared to take part in the discussion, but there was one small matter which might interest the meeting, and he placed the responsibility for showing it on Dr. Peter, because he very kindly encouraged the speaker to do so. He wished to thank Dr. Peter very much indeed for his splendid paper.

Many of those practising abroad had not got some of these instruments on hand, and sometimes they were sent for to see special cases. While he was on leave in the Himalayas, he was sent for a long distance to see a most important man in India. On arrival, he found the patient had got glaucoma. His services, at that time especially, were so valuable to the Empire, that operation could not be thought of unless it proved to be absolutely imperative. He, the speaker, borrowed a black billiard cloth and put it against the wall, and, with the help of an assistant, he mapped out with chalk his scotoma. He then put in eserin and took another tracing on the black cloth, and put over it tracing paper, and opposite the white marks he put the black marks on the tracing. He saw the patient every six weeks, under the same conditions exactly, taking a tracing and placing it over the others, so that he was able to know exactly what was the course of the scotoma. Dr. Peter and Colonel Elliot would bear him out that this was a valuable indication as to one's duty in a case. The patient was able to avoid operation and continue his work for ten months, and he felt very happy about the case because he knew him to be safe. His advice was that that gentleman should be trephined. His advice was not taken, and he went to somebody else and had iridectomy done. He came back, and then the scotoma was nearly on to the fixation point. He again told the patient he must be trephined, and it was done, by a gentleman in this room, and the sight was saved.

He mentioned the incident because such extemporised methods were useful to men practising abroad, where they had not the advantage of such instruments as those shown and spoken of to-day.

Mr. T. Harrison Butler (Leamington Spa), said that in using the ordinary Bjerrum screen he measured the distances from the centre with Sinclair's tangent scale. In order to measure the angular distances he used a carpenter's rule. The best varieties have

a scale of degrees at the pivot. By opening the scale to 10, 20, 30 degrees, etc., one could apply it to the screen and read off the angular distance of the various scotomata. By this means the reading of the screen could be transferred to Traquair's charts.

Mr. E. Burdon-Cooper (Bath) said the method spoken of to-day had been measurements on the tangent. The blind spot could be measured longitudinally. Remarkably few had adopted the longitudinal method of measuring it. His method of measuring the blind spot was based on the ordinary physiological test. Of two spots on a card one looked at the central one with one eye in such a way that the other spot fell on the blind spot of the eye. By approximating or receding the chart two points could be found on a longitudinal graduated bar where the spot just disappeared or reappeared. The longitudinal distance between these two points was a measure of the blind spot. He had an instrument by which in 30 seconds an accurate measurement of one diameter of the blind spot could be determined. It was an easy method, and quick, and it afforded valuable information.

Mr. E. E. Maddox (Bournemouth) spoke of the usefulness of a hatpin stuck into the side of a small cork for perimetric observations. He had been much interested in, and indebted for, what he had heard to-day, and agreed that large objects appeared to come into the periphery more quickly than did smaller ones. If he watched for a finger coming into his field, he at once saw also his hand, which was further out. For ordinary work, to single out cases for the perimeter, we wanted a rapid method, which would not occupy more than half a minute, and the cork on the white hat-pin which he uses can be so held between the thumb and forefinger, as to give active motion to the head of the pin without any visible motion of the hand, owing to the cylindrical shape of the cork. Thus there was no danger of a complication from any movement of the fingers being seen. He also emphasized the fact that it was best to have a moving object for ascertaining the condition of the periphery of the field. He supposed that indirect vision could be regarded as a kind of scout for the macula, and the peripheral retina had, as its function, the consciousness of large objects, bright objects, or moving objects, in order that, if they were important, the macula might be turned towards them, especially moving objects, in the interests of self-preservation. Moreover, by the use of a moving test-object and causing its vibrations to cease now and then, the patient's statements could be tested for veracity. It was well known that astronomers could see a star better by looking at it a little peripherally, as central vision was not the best for a

bright object. Probably the reason was that the fovea was so precious that Nature had endowed it with amber-coloured spectacles, as it were, instead of having them over the whole eye.

Mr. P. G. Doyne (London) said that in the last few months he had taken a certain number of observations on the blind spot and region in cases of myopia, using Elliot's scotometer chiefly, sometimes Bjerrum's screen. He had not yet taken enough to base definite conclusions on them, but in some, one got appearances similar to Seidel's sign. Where, in myopia, one saw signs of atrophy or stretching in the immediate neighbourhood of the disc, it did not follow that this was a scotomatous area. Often it did not show up as a scotoma at all. Recently he had a case which had a large inferior crescent, about 1 to 2 papilla diameters across, and the blind spot showed no enlargement at all.

Dr. Peter, in replying on the discussion, said he fully appreciated the very generous attention which had been given to the subject, and there had been so many points touched on that he felt repaid for having come simply by that discussion.

He would refer now only to two or three matters. Dr. Hoeve made use of a most apt expression in referring to the direction in which the test-object should be moved when he spoke of "rambling." That was just the term to think of when mapping out fields. As another speaker had pointed out, they did not always want to think of radial movement, but of every possible movement in developing the field when determining the presence of a defect. The rambling method would bring out the points.

Mr. Sinclair spoke of the relationship of this subject to medicine, and that, too, was an exceedingly important matter. He did not think it was fully grasped that more general practitioners should do perimetry in the rough, and, as Major Lister well pointed out, they did not need for that the elaborate apparatus referred to in this discussion. With ordinary blackboards and Snellen's type much could be done.

Dr. Marx had spoken of avoiding annoying appearances from outside when examining, and he, the speaker, agreed that the surrounding field should be kept free from disconcerting objects. And it was very helpful for the operator to wear a grey gown. He believed the time was coming when black would be removed from the screens, and some neutral shade, such as grey, substituted. The new perimeter of Ferree was in grey, and the test-object was a peculiar shade of grey, which corresponded to the brightness of the colour which had been used.

He did not read out that part of his paper which dealt with

fixation and central scotoma: he had been much interested in Dr. Marx's method of determining the fields in the presence of bilateral central scotomata. The method he used was a combination of perimeter and scotometer, one similar to that for measuring squint. The patient was placed in front of a perimeter, and as he could not fix the fixation point, his vision moved out along the line until this point came into view. Then one passed the luminous ophthalmoscope along the arc of the perimeter until it came to the centre of the pupil, and then it was read off in degrees. The measurements were then taken on the other side, above and below. That gave four points by which the patient could absolutely fix. The points could, if the observer chose, be connected by a circle. Then one proceeded to map out the scotomata on a tangent plane.

His good friend Colonel Elliot and he were really closer together on this subject than might be thought. During the few days he had had the opportunity of being present at his home, he had done his best to get him to explain to him his scotometer. To-day he succeeded better by offering a little friendly criticism, which resulted in Colonel Elliot pointing out the excellent features in his campimeter. He agreed that it was an excellent tangent screen. That point was, perhaps, the best of all, because accurate fixation was essential.

With regard to the criticism concerning the blind spot, he was glad to learn that Colonel Elliot's instrument revolved both ways. In passing from the seeing part of the retina to the blind part, it was desirable to go a little further. If the two points were connected, it would result in a sharp angle. In his criticism he referred more to the lateral part than to the blind spot. To say that scotomata in glaucoma developed only from the blind spot was not an accurate statement: they would as frequently develop in the sites he indicated on the diagram, and eventually run into the blind spot and become continuous with it. Fuchs said that the nerve fibres on the periphery of the blind spot supplied the part of the retina which was in immediate juxtaposition, and then travelled further and further, until one saw the raphe and sometimes the longer fibres might be affected first. He considered that Colonel Elliot's instrument was one of the best, and that those who possessed it would continue to use it, and that those who had not got it would buy one.

He was glad Major Lister narrated that very practical method of working under difficult conditions. He showed that simple methods could reveal valuable information.

ANNOTATIONS

Eyestrain in Cinemas

The interim report of the joint committee appointed by the Illuminating Engineering Society last year, recently published in the journal of that Society, is noteworthy in that it is the result of investigations by a committee composed of representatives of Engineering, Ophthalmology, Physiology, the London County Council (Public Health, Education, and Fire Departments), and the Cinema Industry.

The recommendations contained in the report (see p. 482) are the result of critical examination of the conditions actually existing in cinema halls in London visited by members of the committee. The point to which attention has been primarily directed is the angle of elevation of the screen seen from seats in the front part of the hall.

It has for long been recognized that eyeache and headache are frequently induced by prolonged observation of pictures and other objects at a level much above that of the observer. Hence the proximity of seats to the screen and the height of the screen are matters of importance. The Committee's judgment that the angle of elevation should not exceed 35°, is one that entails no practical difficulties and one which it is to be hoped will be made obligatory in halls in which, at the present time, this condition does not obtain.

The practical and common-sense recommendations and suggestions of the Committee deserve, and, we trust, will obtain the careful consideration of those concerned in the construction and lighting of new cinema theatres.

The result of the further labours of the Committee will be awaited with interest.

"Suspended Journals"

There is an element of sly malice underlying an editorial dealing with "suspended journals," recently published by the *American Journal of Ophthalmology*. From the note by our contemporary it appears that in its issue of May-June, 1918, the *Centralblatt f. praktische Augenheilkunde*, referring to the consolidation of ophthalmic journals that had taken place during the war, rehearsed with evident pride the list of seven German periodicals devoted to ophthalmology, of which all were in existence. The *Centralblatt* itself, however, ceased publication with the issue of the December,

1919, number. We also note that that most useful publication, Michel's (once Nagel's) *Jahresbericht*, has ceased to exist. At the close of the war it was announced that a single volume covering the period of the war was in preparation.

Help for the Blind

The text of the Government Bill to promote the welfare of blind persons, which came into operation on September 10, 1920, deserves universal approval. Its chief provision is that every blind person who has attained the age of 50 shall be entitled to such pension as, under the Old Age Pensions Act, 1908 to 1919, he would be entitled to if he had reached the age of 70. But that is not all. County and Borough Councils are authorized to provide and to maintain or to contribute towards workshops, hostels, homes, or other places for the reception of the blind. With the approval of the Minister of Health, they may make such further arrangements for the welfare of blind persons as they may think fit. The measure applies to Scotland and to Ireland. Its short title will be "The Blind Persons Act, 1920."

In this connection it may be noted that a memorandum has been issued by the Board of Education dealing with the training of blind students. The chief object of the Board is to provide a link between the special school giving primary education, on the one hand, and the workshop, on the other. The Board is prepared materially to increase the grants it makes in aid of training institutions, and these and other grants mentioned in the memorandum will be retrospective as from April 1, 1919.

INTERIM REPORT OF THE JOINT COMMITTEE APPOINTED BY THE ILLUMINATING ENGINEERING SOCIETY TO ENQUIRE INTO "EYE-STRAIN IN CINEMAS"*

THIS Committee was formed in response to a request conveyed to the Illuminating Engineering Society from the London County Council (April 28, 1919) for information as to possible causes of eye-strain in cinemas, and the best means of removing them, and in particular "The question of the strain on the eyes caused by the proximity of seats to the screen at cinematograph halls, and of the possibility of devising some means of lessening the ill-effects

* Reprinted from the *Illuminating Engineer*, June, 1920.

referred to." A joint committee, representing the Council of British Ophthalmologists, the Physiological Society, the Illuminating Engineering Society, the Cinema Industry, and the London County Council, was appointed, the whole being presided over by Mr. J. Herbert Parsons, C.B.E. The Council of British Ophthalmologists sent Messrs. B. Cridland, M. S. Mayou, W. H. McMullen, O.B.E., and J. Herbert Parsons, C.B.E.; the Physiological Society was represented by Professors W. M. Bayliss, F.R.S., C. S. Sherrington, F.R.S., and C. Spearman. Dr. James Kerr represented the Public Health Department of the London County Council.

Meetings were held, sub-Committees appointed, experimental demonstrations witnessed, and cinema halls visited, and the following recommendations and suggestions embodied in an interim report dated June, 1920:

Limit to vertical angle of view (angle of elevation).—In considering the question of close proximity of seats to the screen the Committee have formed the opinion that the ocular discomfort arising is due mainly to the fact that the eyes of spectators are directed upwards at an abnormal angle, a condition which is conducive to eye-fatigue and liable to give rise to headache and general discomfort; whereas the direction of the eyes horizontally or downwards appears natural and agreeable. The condition of discomfort referred to is not determined solely by the proximity of the front row of seats to the screen and the vertical measurement of the picture. Another important circumstance is the height above the observer's eye-level at which the picture as a whole is viewed. It would therefore not suffice to specify a minimum distance of seats from the screen, nor even a certain ratio between this distance and the vertical measurement of the picture. The requirement should include all the three factors enumerated above, but should be of a simple and definite character, capable of easy application.

The Committee, in determining such a requirement, have been guided partly by the knowledge of the physiological and ophthalmological experts on conditions liable to cause discomfort and fatigue to vision, and also on the experience of all the members of the Committee, when visiting a number of cinema halls in the London district. In each case the pictures were viewed successively from various rows of seats, the positions from which discomfort and eye-strain were experienced noted, and the corresponding angles of elevation recorded. In framing a general recommendation based on these experiences, due account was taken of such variable factors as the proportion of screen occupied by the picture and the extent to which the eye is directed respectively to the upper, central and lower areas of the screen, with the ordinary available seating accommodation.

In some of the cinema halls visited the conditions were found to be such as are likely to cause visual discomfort and eye-strain. By comparing the record of their experience in this respect with the tabular data summarising the angles of elevation in the various cinemas visited, the Committee came to the conclusion that it would be possible to secure conditions suitable for the eyes, and to diminish the possibility of eye-strain materially if a moderate value for the angle of elevation were adopted. It appeared that the desired conditions could be suitably expressed by stating that the angle of elevation, conveniently measured from the top of the picture as defined below, should not exceed 35°—a simple and easily interpreted recommendation which is to be regarded as embodying all the various factors mentioned above.

The Committee accordingly make the following recommendation :—

" (1) That the angle of elevation, subtended at the eye of any person seated in the front row, by the length of the vertical line dropped from the centre of the top edge of the picture to the horizontal plane passing through the observer's eye shall not exceed 35°, the height of the eye above floor-level being assumed to be 3 ft. 6 in."

Investigations have shown that in some cinema halls in London this condition is complied with, while in others it is approached. In other cases the angle of elevation exceeds 60°—a condition that is clearly prejudicial and could be removed by eliminating some of the seats in the front rows. It should be noted that in such cases it may not be necessary to eliminate a complete row of seats, as in the seats nearer the sides of the hall the angle of elevation is less than in those immediately facing the screen, and may fall within the prescribed value of 35°. The most favourable condition is thus to arrange the seats in an arc of a circle, the concave edge of which faces the screen—an arrangement already adopted in some modern cinema halls.

The limiting circle, corresponding with an angle of elevation of 35°, will have as its centre the intersection of a vertical line from the centre of the top of the screen with the horizontal plane at eye-level (3 feet 6 inches above floor); and as its radius a distance equal to 1·43 (i.e., rather less than one-and-a-half) times the height of the top of the picture eye level.

Limit to lateral angle of view.—Assuming that the above recommendation (i.e., that the angle of elevation should not exceed 35°) is complied with, the effect of viewing the screen at an unduly oblique angle from side seats requires to be considered. While this condition is productive of inconvenience and constitutes a possible source of eye-strain, it appears to be of less importance than the avoidance of an unduly great angle of elevation.

The Committee accordingly make the following recommendation, which has been framed to apply equally to cases where vertical or inclined screens are used:

"(II) That, provided recommendation (I) is complied with, the angle between the vertical plane containing the upper edge of the picture, and the vertical plane containing the observer's eye and the remote end of the upper edge of the picture should not be less than 25°."

Minimum distance of seats from screen.—The Committee has had under consideration the question of undue proximity to the screen as a source of difficulty in following movements in the picture, leading to possible eye-strain. While conscious that undue proximity to the screen impairs the ease with which pictures can be examined, the Committee are of opinion that compliance with requirements (I) and (II) renders further recommendations in regard to such distance unnecessary at present.

Maximum distance of seats from screen.—It is clear that a limit to the distance of observation beyond which it is difficult to distinguish pictures satisfactorily, exists, although managers of halls will usually ensure, in their own interest, that this limit is not exceeded. It has been suggested that the angle subtended at the eye by the height of the screen, viewed from the most remote seat, should not be less than 5°, or alternatively, that the distance of the most remote seat should not exceed twelve times the height of the picture. The Committee, however, require further evidence before making recommendations on this point, and in the data at present collected, no case has been noted in which the above suggested limit has been exceeded.

Flicker.—There are several phenomena which are included in the common use of the term flicker, and have been the subject of investigation by the Committee. The two most important for our purpose are:

(a) **Physiological flicker.**—This occurs when light and dark are alternated. It disappears at a certain critical rate of alternations which rate depends upon the brightness of the illumination. It is most noticeable with the periphery of the retina so that on a large screen it may be absent from the part of the screen directly looked at, though the observer is conscious of the flicker on the outlying parts of the screen. Under normal conditions of projection no appreciable physiological flicker is observable in the pictures unless there is a large expanse of brightly illuminated screen (e.g., sky or snow field).

(b) **Disintegration flicker.**—The pictures shown on the screen are composed of a series of rapidly succeeding pictures which are integrated physiologically and should give the impression of continuous movement. Under certain conditions, e.g., figures

moving rapidly in the foreground, especially from side to side, the separate impressions become perceptible—an effect which is most noticeable near the screen, but is frequently visible from all parts of the hall. It is possible that the effect might be minimised by taking more pictures per second and projecting at a correspondingly increased rate, but this presents technical difficulties.

Of all the disturbing factors manifesting themselves by jerkiness of movement, disintegration flicker is undoubtedly the most serious.

Film and mechanical defects.—The Committee have devoted attention to various irregularities arising from defects in films or apparatus. Scratches on old films give rise to an appearance of vertical black lines like rain. Holes in the gelatine cause flecks of light. Worn sprocket holes, and mechanical defects arising from instability of apparatus may give rise to disturbing effects. Various promising improvements in projecting apparatus and screens have been brought before the Committee.

While the elimination of imperfect apparatus and films, and faulty operation, such as may occur in halls in the poorer districts, is much to be desired, the Committee do not at present see their way to recommend a definite criterion by which to condemn the exhibition at any particular theatre.

Brightness of screen.—The Committee have made a series of measurements of the brightness of screens while pictures are being shown. Here, again, faulty apparatus, involving inadequate screen brightness, undoubtedly increases the difficulty of following pictures. The observations of the Committee suggest that a possible standard of minimum brightness may eventually be given, but their researches on this point are as yet incomplete, bearing in view the great variations in light required with different subjects, films of different density and different types of screens.

Portable cinema outfits for schools.—The Committee have witnessed some demonstrations of the use of portable cinema outfits for schools, a type of device which appears to be in the experimental stage but has promising possibilities, and in view of the growing demand for apparatus of this type improvements may be anticipated in the near future.

As an educatioual medium the cinema has possibilities, but in view of the fact of its being intended for display before young children, the conditions of use for exhibitions in schools require careful consideration. One difficulty at present is to obtain a portable light of sufficient brightness which can be obtained from the electric lighting supply usually available. In order to render the picture sufficiently visible it is necessary to darken the schoolroom by the use of blinds, and it would be advantageous to have the screen recessed and surrounded by a narrow curtain, with a view to further protection of the screen from extraneous light.

In order to secure additional brightness, semi-polished aluminium screens are sometimes used. In this way the brightness, to observers immediately facing the screen, is much increased, but the brightness as seen from side seats is seriously diminished. From the experiments conducted by the Committee they are disposed to prefer a dead white screen for general use and recommend that aluminium screens should only be used in exceptionally long and narrow rooms, where the angle of lateral view does not become unduly oblique.

Another point to be considered is the method of fixing the projecting apparatus, which, owing to its lightness, is apt to vibrate, causing unsteadiness in the picture.

Inflammability of films as a possible source of danger of fire demands special precautions in such cases, but this is not a matter falling within the terms of reference of the Committee.

Conditions of artificial illumination in theatres.—In accordance with the Council's recent requirement a minimum standard of illumination is now generally maintained in theatres whilst the pictures are being shown. From the observations already made in cinema halls the Committee are satisfied that the requirement that the illumination in all parts of the theatre should not be less than 1-40th of a foot candle can be readily satisfied without prejudice to the picture. Indeed there seems no doubt that by using suitable methods of distributing the light this illumination might be somewhat increased without interfering with the display of the pictures. A practice that might well be encouraged when the design of the lighting of the halls is under consideration, is the gradual diminution of the intensity of illumination, passing from the rear of the theatre (where illumination is chiefly needed to facilitate the work of the attendants), to the seats near the screen where stray light is most apt to affect the picture on the screen (and where such illumination is less needed because the seats are to some extent illuminated by light reflected from the screen). This practice would also be advantageous in facilitating the accommodation of the eyes of persons, passing from the bright light outside into the relatively dark interior of the hall. Recommendations in regard to arrangements of light with a view to conforming with the requirements of vision as regards absence of excessive contrast and glare are also in contemplation. Meantime the Committee would suggest as a definite rule, already observed in the best cinema halls, that no unscreened source of light should be visible to the observer in any seat in the theatre whilst looking towards the picture.

In conclusion the Committee desire to draw attention to Recommendation (I) relating to the Angle of Elevation, and Recommendation (II) relating to the Lateral Angle of View, as embodying conditions which appear desirable in cinema halls. The

Committee do not anticipate that any supplementary recommendations which they may submit as a result of their further inquiries will necessitate any modification of the two recommendations now submitted.

The three representatives of the cinema industry while approving Recommendation No. I of the foregoing Report as an ideal one, which would add greatly to the comfort of the public, draw attention to the absence of definite evidence of serious injury by eye-strain. In view of this fact they are of the opinion that where application of this condition to existing halls would entail serious financial hardship there is no justification for its imposition. They are further of the opinion that the normal development of the cinema theatre will rapidly remove all causes of possible discomfort.

NOTES

Deaths

WE regret to announce the death at St. Louis, Mo., on June 28th last, of Adolf Alt at the age of 69 years, after an illness of many months' duration. He was born at Mannheim, Germany, and was the son of Dr. Dettmar Alt. In 1875 he graduated in medicine at the University of Heidelberg, and soon migrated to Canada, where he was appointed lecturer on ophthalmology and otology in the Trinity Medical School, Toronto. His well known "Lectures on the Human Eye in its Normal and Pathological Conditions," appeared in English in 1880, having been translated from the German "Histologie des Auges." Alt settled in St. Louis, Mo., in 1885, the year after he had founded the *American Journal of Ophthalmology*, and when that journal was merged in the newer periodical of that same name, Alt retained his editorial connection with the journal. He was a member of the American Ophthalmological Society.

Samuel Éperon, professor of ophthalmology in the University of Lausanne, died shortly after a surgical operation. He was born in 1857, studied at Geneva, Leipsig, Würzburg, and Paris, and acted as assistant to Landolt in the city last-named. He is one of the editors of the *Revue Générale d'Ophtalmologie*. He succeeded Marc Dufour in the Chair of Ophthalmology in 1910.

Richard Nunn, who was educated at Trinity College, Dublin, died at Oregon on August 17, 1920. He was Professor of Diseases of the Eye, Ear, Nose, and Throat, at Oregon University.

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